

REMARKS

The above amendments to the above-captioned application along with the following remarks are being submitted as a full and complete response to the Official Action dated October 28, 2005. In view of the above amendments and the following remarks, the Examiner is respectfully requested to give due reconsideration to this application, to indicate the allowability of the claims, and to pass this case to issue.

Status of the Claims

Claims 2-3, 5-6, 8-11, 13-14, 16-17 and 19-26 are under consideration in this application. Claims 2, 3, 10 and 11 are being amended, as set forth in the above marked-up presentation of the claim amendments, in order to more particularly define and distinctly claim applicants' invention. New claims 23-26 are hereby submitted for consideration. All the amendments to the claims are supported by the specification. Applicants hereby submit that no new matter is being introduced into the application through the submission of this response.

Prior Art Rejections

The Examiner rejected claims 2-3, 5-6, 8-11, 13-14, 16-17 and 19-22 under 35 U.S.C. § 102(e) or under § 103(a) as being anticipated by or unpatentable over van de Veerdonk et al. (2003/0235717). This rejection has been carefully considered, but is most respectfully traversed.

The present invention as currently recited in claim 2 is directed to a perpendicular magnetic recording medium including a substrate and a magnetic layer formed on the substrate, the magnetic layer comprising multilayer superlattice films of ferromagnetic metal layers which contain Co and paramagnetic metal layers which consist of Pd and/or Pt, the magnetic layer consisting of columnar magnetic grains and magnetic grain boundaries that surround the magnetic grains, and a thickness of the paramagnetic metal layers being 0.8 nm or less. The magnetic layer has a rate of decrease in coercivity defined by the multilayer superlattice films of ferromagnetic metal layers being formed by sputtering deposition with a distance D_{TS} between the substrate and target areas of the multilayer superlattice films of ferromagnetic metal layers defined such that a product ($P_O * D_{TS}$) of a sputtering gas pressure P_O and the distance D_{TS} is at least 20 Pa*cm. The rate of decrease in coercivity of the magnetic layer, if exposed to extreme temperature change, is less than 0.15 when the rate is

evaluated by a formula: $[H_c \text{ at 25 degrees Celsius} - H_c \text{ at 70 degrees Celsius}] / H_c \text{ at 25 degrees Celsius}$, where H_c is the coercivity of the magnetic layer.

As set forth in claim 3, the present invention is directed to a perpendicular magnetic recording medium including a substrate and a magnetic layer formed on the substrate, the magnetic layer comprising multilayer superlattice films of ferromagnetic metal layers which contain Co and paramagnetic metal layers which consist of Pd and/or Pt, the magnetic layer consisting of columnar magnetic grains and magnetic grain boundaries that surround the magnetic grains, and the thickness of the paramagnetic metal layers being 0.8 nm or less. The magnetic layer has a rate of decrease in coercivity defined by the multilayer superlattice films of ferromagnetic metal layers being formed by sputtering deposition with a distance D_{TS} between the substrate and target areas of the multilayer superlattice films of ferromagnetic metal layers defined such that a product $(P_0 * D_{TS})$ of a sputtering gas pressure P_0 and the distance D_{TS} is at least 20 Pa*cm. When a magnetic torque loop of the perpendicular magnetic recording medium is measured with a torque magnetometer, the polarity of a value of loop components with translational symmetry of 90 degrees is opposite to the polarity of a value of loop components with translational symmetry of 180 degrees.

As set forth in new claim 23, the present invention is directed to a perpendicular magnetic recording medium including a substrate and a magnetic layer formed on the substrate, said magnetic layer comprising: multilayer superlattice films of ferromagnetic metal layers which contain Co and paramagnetic metal layers which consist of Pd and/or Pt, said magnetic layer consisting of columnar magnetic grains and magnetic grain boundaries that surround the magnetic grains, and a thickness of said paramagnetic metal layers being 0.8 nm or less.

Applicants will first point out that the present invention specifically claims and defines that the ferromagnetic and paramagnetic layers of the present invention are each formed as a collection of microscopic columnar magnetic grains separated by the grain boundaries that constitute a magnetic array columnar structure in which the grains are segregated with boundaries on the entire surface of the ferromagnetic or paramagnetic layer, the grain boundaries consisting of either sparse amorphous materials or simply voids (see specification page 3, lines 9-25; page 6, line 9 to page 7, line 11; Figure 1). Applicants had found that this structure for the ferromagnetic and paramagnetic layers is advantageous in recording/readback performance as compared to conventional magnetic recording media. However, Applicants further found that this structure also had the initial problem of its

performance being sensitive to temperature changes. One of the main purposes of the invention is to address the performance problem caused by temperature variations in a multilayer superlattice structure.

In order to solve the above-noted problem, Applicants have found first that by controlling the thickness of the paramagnetic layers to 0.8 nm or less, the magnetic moment in the layers and the K_u constant is stable even with severe temperature rises. Further, Applicants found that increasing the product of gas pressure P_{Ar} in the chamber during a sputtering process and the distance D_{TS} between the substrate and the targets, $P_{Ar} \cdot D_{TS}$ contributes to stabilizing the magnetic moment in the paramagnetic layer, thus suppressing the temperature-dependent change of the K_u constant. The magnetic moment induced in noble metal atoms in the superlattice is stable even in the positions away from the interface between the ferromagnetic metal layer and the paramagnetic layer because the noble metal atoms are exactly arranged in an intended crystalline structure (see specification, page 18, line 3 to page 19, line 5).

Applicants respectfully contend that Veerdonk '717 fails to teach or suggest the magnetic layer comprising multilayer superlattice films of ferromagnetic metal layers which contain Co and paramagnetic metal layers which consist of Pd and/or Pt, the magnetic layer consisting of columnar magnetic grains and magnetic grain boundaries that surround the magnetic grains, and a thickness of the paramagnetic metal layers being 0.8 nm or less, wherein the magnetic layer has a rate of decrease in coercivity defined by the multilayer superlattice films of ferromagnetic metal layers being formed by sputtering deposition with a distance D_{TS} between the substrate and target areas of the multilayer superlattice films of ferromagnetic metal layers defined such that a product ($P_o \cdot D_{TS}$) of a sputtering gas pressure P_o and the distance D_{TS} is at least 20 Pa*cm, so as to provide (1) the rate of decrease in coercivity of the multiplayer superlattice films of ferromagnetic metal layers is less than 0.15 (claim 2); and (2) when a magnetic torque loop of the perpendicular magnetic recording medium is measured with a torque magnetometer, the polarity of a value of loop components with translational symmetry of 90 degrees is opposite to the polarity of a value of loop components with translational symmetry of 180 degrees as the invention (claim 3).

Rather, Veerdonk '717 merely discloses a conventional multilayer magnetic structure having multiple magnetic layers 22 separated by nonmagnetic or spacer layers 24. Each magnetic layer 22 comprises a composite material with a discontinuous magnetic phase in the form of platelets 26 and a continuous nonmagnetic phase 28 (see ¶¶ [0019] to [0022]).

Typically, the magnetic 26 and nonmagnetic 28 materials are deposited via conventional sputtering techniques, and may be afterwards annealed (see ¶¶ [0024] to [0026]). In essence, the magnetic layer 22 is composed of islands of platelets in a nonmagnetic layer. More specifically, unless otherwise recited by Veerdonk '717, it must be assumed that the platelets 26 and continuous magnetic phase 28 are formed using conventional techniques. At best, Veerdonk '717 only mentions that the magnetic platelets 26 may be formed using "superlattices chemically synthesized nano-particle structures, such as FePt particles with small diameter" (see ¶ [0031]). This simply means that only the platelets may be formed as superlattices, and only based on FePt particles with small diameters in order to preserve the structure of platelets 26 having limited diameters separated by a continuous nonmagnetic phase 28.

With respect the nonmagnetic spacer layers 24, Veerdonk '717 discloses that it may comprise any suitable material, such as Pt, Pd, Au and combinations thereof, wherein the nonmagnetic spacer layers 24 are typically formed by deposition processes such as sputtering, evaporation or ion beam deposition (see ¶ [0023]). Otherwise, this reference is completely silent as to the structure and composition of the spacer layers 24. Thus, this reference cannot and does not disclose or suggest that the spacer layers 24 could be formed as part of a superlattice structure.

Consequently, Veerdonk '717 does not show or suggest that its magnetic recording structure 20, namely the combination of the composite layer 22 and the nonmagnetic spacer layer 24, could in any way embody a superlattice structure as defined in the present invention.

Further, Applicants will strongly but respectfully contend that the structure of Veerdonk '717, as described above, is in fact considerably different from that of the present invention as claimed, and thus cannot embody or address the nuances associated with a superlattice structure, such as that claimed for the present invention. In particular, since the structure of Veerdonk '717 is not directed to a magnetic layer formed from multilayer superlattice films, this reference cannot identify the problems associated with such a structure, much less embody the solution to such problems. As noted above, Veerdonk '717 at best teaches that only the platelets in the composite magnetic layer 22 are formed as superlattices. However, in the present invention, the paramagnetic layers are also part of the superlattice structure and it is the structure of the paramagnetic layers as part of a superlattice structure that is among the main features of the present invention.

More specifically, Applicants will point out that the desired thickness for the paramagnetic layer of the present invention is 0.8 nm or less. This is important because the desired characteristics of the present invention are achieved at that lower range, as illustrated in Figures 9 and 10. In particular, decreases in coercivity and in the K_u constant due to temperature changes are avoided when the thickness of the paramagnetic layer is 0.8 nm or less.

In contrast, even though the Examiner points out that, in paragraph [0020], this reference discloses that the “each nonmagnetic spacer layer 24 has a thickness T_n typically of from about 0.6 to about 3 nm, for example, from about 0.8 to about 1.5 nm, if the teachings of Veerdonk ‘717 of a thickness of 0.6 to 3 nm were applied to Figures 9 and 10, it is evident that the major part of that thickness range falls in the region where values for both coercivity and the K_u constant are well within the undesirable range of decreasing. Applicants will contend that one of skill in the art would not appreciate the characteristics achieved by the present invention in view of Veerdonk ‘717 due to the fact that, at least with the spacer layers, this reference not only does not provide any specific teaching as to the structure or composition of the spacer layers, but instead does teach, as the typical or desired thickness, a range that is predominantly undesirable for the structure and operation of the present invention. Thus, Applicants will contend that one of skill in the art would not use the teachings of Veerdonk ‘717 in order to achieve, teach or much less suggest the present invention.

As such, the present invention as now recited in independent claims 2-3 is distinguishable and thereby allowable over the rejection raised in the Office Action. The withdrawal of the outstanding prior art rejections is in order, and is respectfully solicited.

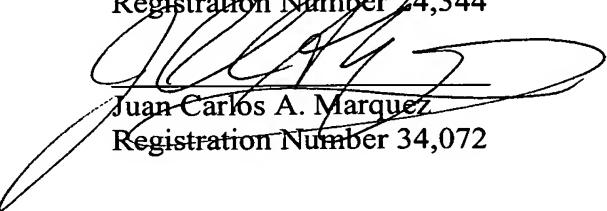
Conclusion

In view of all the above, clear and distinct differences as discussed exist between the present invention as now claimed and the prior art reference upon which the rejections in the Office Action rely, Applicant respectfully contends that the prior art references cannot anticipate the present invention or render the present invention obvious. Rather, the present invention as a whole is distinguishable, and thereby allowable over the prior art.

Favorable reconsideration of this application is respectfully solicited. Should there be any outstanding issues requiring discussion that would further the prosecution and allowance of the above-captioned application, the Examiner is invited to contact the Applicants' undersigned representative at the address and phone number indicated below.

Respectfully submitted,

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